KOKAI PATENT APPLICATION NO. HEI 4-172169

FIBER-REINFORCED METAL-BASED COMPOSITE MEMBER

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FIBER-REINFORCED METAL-BASED COMPOSITE MEMBER

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[*There are no amendments to this patent.*]

[*Translator's note: Names of products and companies are spelled phonetically in this translation.*]

Specification

1. Title of the invention

Fiber-reinforced metal-based composite member

2. Claims of the invention

A fiber-reinforced metal-based composite member subjected to compressive force, which fiber-reinforced metal-based composite member is characterized by the fact that a layer made of two different types of fiber consisting of a continuous fiber uniaxially oriented in the direction of the force and a randomly oriented short fiber is formed as a composite matrix at least for the member to which the compressive force is to be applied.

3. Detailed description of the invention

[Field of industrial application]

The present invention pertains to a fiber-reinforced metal-based composite member in which the portion to which a compressive force is applied is a fiber-reinforced member.

[Prior art]

It is desirable when the weight of machine parts to be assemble in vehicles are lightweight when energy-savings during production as well as at the time of operation of the vehicle are taken into consideration. Thus, lightweight metal castings made of materials such as aluminum alloys or magnesium alloys are being used for parts of machines, but the mechanical characteristics such as rigidity, creep resistance, and impact and abrasion resistance under high temperatures are inferior compared to cast iron, and damage and deformation are likely to occur to the parts or in the region where they join with other parts. Therefore, a separate material is used for joints where high strength is required to increase the strength of the joint, but an overall weight increase results and practical use poses many problems, and a satisfactory material has not been available. Based on the above background, a fiber-reinforced junction is proposed. A fiber-reinforced metal-based composite member in which a fiber reinforced layer is formed at the junction with other machine parts is described in a publication such as Japanese Kokoku [Examined] Patent Application No. Sho 56-35981.

In this case, packing of the matrix is performed in a fiber molded article made of an inorganic fiber or metal fiber using a high pressure coagulation casting method.

A fiber-reinforced composite member where reinforcement is imparted to the area where a compressive force is applied by means of short randomly-orientated fibers, good performance can be achieved with regard to forces applied at random.

[p. 2]

However, when the reinforcement fiber is randomly oriented in a two-dimensional plane normal to the direction of the applied stress, hardly any effect is achieved.

Furthermore, with regard to the above-mentioned creep deformation, a continuous fiber uniaxially orientated parallel to the direction of the applied force is most effective.

However, the bonding strength among fibers is poor for stress applied to the fibers in the longitudinal direction and cross direction in a fiber-reinforced composite member made with the above-mentioned continuous fiber alone; thus, layer destruction is likely to occur.

When the member undergoes creep deformation, stress is applied is applied to the composite member in a direction other than the longitudinal direction of the fiber; thus, said member undergoes layer destruction.

Furthermore, the strength of the molded fiber-reinforced article is poor; thus, shape retention of the molded article is difficult to achieve, and productivity is reduced.

[Means to solve the problem]

The purpose of the present invention is to reduced the creep deformation of parts subjected to a compressive force and to produce a fiber-reinforced composite member having a high strength in the region to which said compressive force is applied.

In this case, a specific force is imparted for orientation of the reinforced fiber.

[Means to solve the problem]

In other words, with regard to a fiber-reinforced metal-based composite member subjected to a compressive force, the present invention is a fiber-reinforced metal-based composite member characterized by the fact that a layer made of two different types of fiber consisting of a continuous fiber uniaxially oriented in the direction of the applied stress and a short randomly-orientated fiber is formed in a composite matrix for least the member to which the compressive force is to be applied.

[Work of the invention]

The reinforced fiber is reduced to the part of the cast member impressed with a compressive force using a uniaxially orientated continuous fiber, and the strength in directions other than the direction of compression is increased by a randomly oriented short fiber. When a material containing the above-mentioned two different fiber layers at the same time is formed, it is possible to obtain a fiber-reinforced composite member with the properties of both.

[Application Examples]

In the following, the present invention is explained further with application examples.

[First application example]

An application example in which an evaluation of the compression creep resistance when the present invention is used for the bolt seat surface is shown below.

Seat 1 (fiber volumetric proportion: 10%) having a thickness of 5 mm and made of 47 wt% alumina-53 wt% silica fiber ("Kao-Wool", product of Isolite Co., Ltd.) with a mean fiber diameter of 2.8 μm and mean fiber length of 600 μm, and seat 2 (fiber volumetric proportion: 60%) having a thickness of 3 mm and made of a continuous carbon fiber ("Toreka", product of Toray Co., Ltd.) with a mean fiber diameter of 6.5 μm were arranged as shown in Fig. 2 and wrapped around to produce a cylindrical molded article having a height of 40 mm, inner diameter of 35 mm and outer diameter of 55 mm. Furthermore, two different types of fiber molded articles, namely, the fiber molded article of invention 1 shown in Fig. 3 where the orientation of the continuous fiber (Toreka) is in the direction of the applied stress, and the orientation of the short fiber (Kao-Wool) is two-dimensionally random at the inner surface in the stress direction, and the fiber molded article of invention 2 shown in Fig. 4 where the continuous fiber (Toreka) has a two-dimensional random orientation in a plane normal to the stress direction, were prepared.

The above-mentioned fiber-molded article was made into a composite with an aluminum alloy melt (JIS: AC4C) using a high pressure casting machine and production of invention 1 and invention 2.

The above-mentioned inventions were used at the bolt seat shown in Fig. 1.

Fig. 1 is a cross-section view that shows cast member 1 made of an aluminum alloy that is applied to cast iron block 4 with bolt 3 via cast iron plate 2.

The composite member 5 of the cast member 1 is reinforced with continuous fiber 6 oriented in a direction parallel to the direction of the stress applied by bolt 3 and the short fibers 7 are randomly oriented.

The above-mentioned bolt seat is fastened under the stress of the bolt 30 Kgf/mm^2 and stored in an oven at 150°C and measurements were made of the axial tension for 1000 h.

For comparison, an evaluation was made in the same manner for comparison products 1 through 7 described below and shown in Fig. 5 through Fig. 10.

Comparison product 1: aluminum alloy without reinforcement fiber (AC4C)

Comparison product 2: As shown in Fig. 5, a fiber-reinforced composite member in which the orientation of the continuous (Toreka) is perpendicular to the direction of the stress and the orientation of the short fiber (Kao-Wool) is the same as in invention 1.

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Comparison product 3: As shown in Fig. 6, a fiber-reinforced composite member in which the orientation of the continuous (Toreka) is perpendicular to the direction of the stress and the orientation of the short fiber (Kao-Wool) is the same as in invention 2.

Comparison product 4: As shown in Fig. 7, a fiber-reinforced composite member in which the orientation is parallel to the direction of stress and the fiber reinforcement is provided with the continuous fiber (Toreka) alone.

Comparison product 5: As shown in Fig. 8, a fiber-reinforced composite member in which the orientation is perpendicular to the direction of the stress and the fiber reinforcement is carried out with the continuous fiber (Toreka) alone.

Comparison product 6: As shown in Fig. 9, a fiber-reinforced composite member in which the orientation is two-dimensionally random in the direction of stress at the peripheral surface and fiber reinforcement is done with the short fiber (Kao-Wool) alone.

Comparison product 7: As shown in Fig. 10, a fiber-reinforced composite member in which the orientation is two-dimensionally random in the direction perpendicular to the direction of stress, and fiber reinforcement is provided with the short fiber (Kao-Wool) alone.

The results obtained above are shown in Fig. 11.

As shown in Fig. 11, the present invention is about the same as in the case of Comparison Product 4 where reinforcement is provided with the continuous fiber (Toreka) uniaxially orientated in the direction of the stress, and higher compressive creep resistance can be achieved in comparison to the other comparison products.

As shown above, excellent compressive creep resistance can be achieved when a continuous fiber uniaxially oriented in the direction of the stress is used.

Furthermore, when a continuous fiber sheet oriented in the direction and randomly oriented short fibers are wrapped around and arranged to form a cylinder, a cylindrical molded article can be easily produced.

Furthermore, when the above-mentioned overlaid sheets are wrapped around many times in the form of a spiral, the joints of a sheet are eliminated, and continuity of the long fiber in the diameter direction can be prevented, and delamination at the portion reinforced by the long fiber can be prevented.

The tightening of the bolt was increased and a compression test was carried out.

As a result, a layer destruction was observed in comparison product 4 (continuous fiber uniaxially orientated parallel to the direction of stress orientation and fiber reinforcement is carried out with a continuous fiber alone) under a compression force with a surface pressure of approximately 60 Kgf/mm^2.

As shown in the results obtained above, excellent compression creep resistance can be achieved in a fiber-reinforced composite member reinforced with the above-mentioned continuous fiber uniaxially orientated in the direction of stress but layer destruction is likely to occur.

(Second application example)

Compared to the first application example, a different reinforcement fiber was used and the above-mentioned tests were repeated in the same manner.

Seat 1 (fiber volumetric proportion: 13%) having a thickness of 4 mm and made of 97 wt% alumina-3 wt% silica fiber ("Safil", product of Isolite Co., Ltd.) with a mean fiber diameter of 3.0 μm and mean fiber length of 900 μm, and seat 2 (fiber volumetric proportion: 40%) having a thickness of 4 mm and made of a continuous alumina fiber ("Sumika Alumina", product of Sumitomo Chemical Corp.) with a mean fiber diameter of 17 μm were arranged as in the case of Application Example 1, and wound to produce a cylindrical molded article having a height of 40 mm, inner diameter of 35 mm and outer diameter of 55 mm.

Furthermore, two different types of fiber molded articles, namely, the fiber molded article of invention 3 where the orientation of the continuous fiber (Sumitomo Alumina) is in the stress direction, and the orientation of the short fiber (Safil) is two-dimensionally random at the inner

surface in the stress direction, and the fiber-molded article of invention 4 where the orientation of the continuous fiber (Sumitomo Alumina) is two-dimensionally random in the plane perpendicular to the stress direction, were prepared. The above-mentioned fiber molded articles were made into composites with a magnesium alloy melt (JIS: AZ91) using a high-pressure casting machine and production of composites of invention 3 and invention 4 were achieved.

The above-mentioned inventions were used as bolt seats.

The above-mentioned bolt seats were fastened with a bolt bearing stress of 8 Kgf/mm^2 and stored in an oven at 150°C and the axial tension was measure for 1000 h.

The continuous fiber (Toreka) used in Comparison Products 1 through 7 in Application Example 1 was changed to a continuous alumina fiber (Sumika Alumina), and the short fiber (Kao-Wool) was changed to another short fiber (Safil), and the aluminum alloy used as the matrix was changed to a magnesium alloy, and production of Comparison Products 8 through 14 was carried out, and tests were made of the change in axial tension in the same manner as above. As a result, results similar to those in Application Example 1 were obtained.

[p. 4]

[Effect of the invention]

According to the present invention, the creep deformation for the part to which a compressive force is applied was reduced, and a fiber-reinforced composite member having high strength was produced.

4. Brief description of figures

Fig. 1 is the cross-section view of the fiber-reinforced composite member of the present invention having reinforcement in the direction of stress.

Fig. 2 is an external view of the reinforcement fiber of concern in the present invention.

Fig. 3 is a schematic view of the fiber-reinforced member of invention 1.

Fig. 4 is a schematic view of the fiber-reinforced member of invention 2.

Fig. 5 is the schematic view of the fiber-reinforced member of comparison product 2.

Fig. 6 is the schematic view of the fiber-reinforced member of comparison product 3.

Fig. 7 is the schematic view of the fiber-reinforced member of comparison product 4.

Fig. 8 is the schematic view of the fiber-reinforced member of comparison product 5.

Fig. 9 is the schematic view of the fiber-reinforced member of comparison product 6.

Fig. 10 is the schematic view of the fiber-reinforced member of comparison product 7.

Fig. 11 is a graph that shows the results of the applied stress test.

Explanation of codes

1 ... Cast member

2 ... Cast iron plate

3 ... Bolt

4 ... Cast iron block

5 ... Composite member

6 ... Continuous fiber

7 ... Short fiber

Applicant: Toyota Motor Corporation

Fig. 1

1 ... Cast member

2 ... Cast iron plate

3 ... Bolt

4 ... Cast iron block

6 ... Continuous fiber

7 ... Short fiber

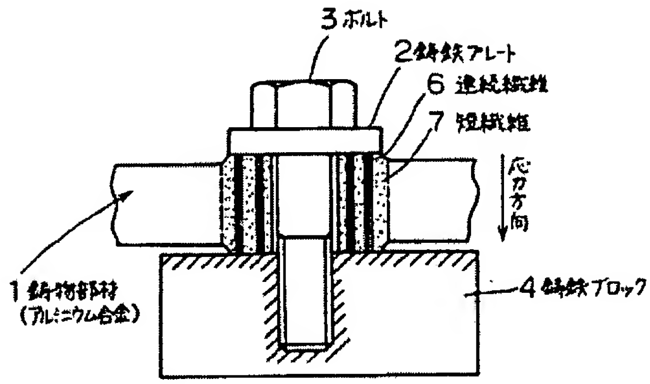


Fig. 2

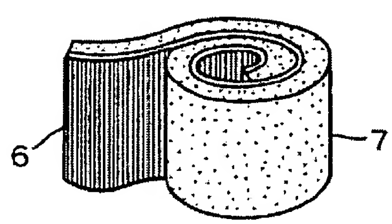


Fig. 3

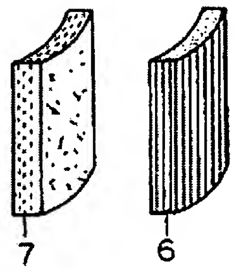


Fig. 4

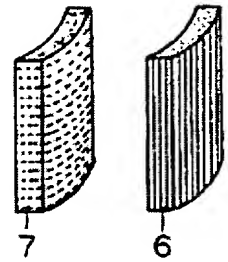


Fig. 5

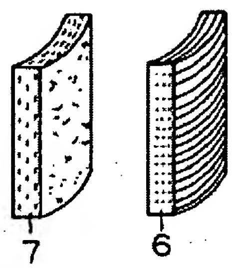


Fig. 6

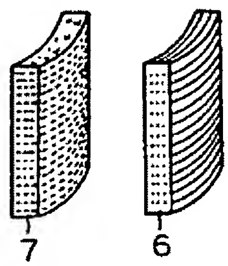


Fig. 7

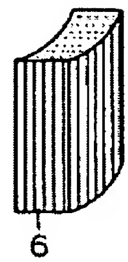


Fig. 8

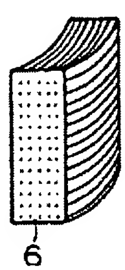


Fig. 9

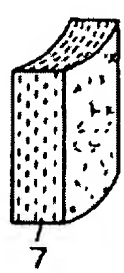


Fig. 10

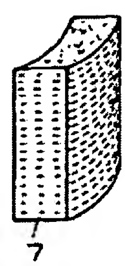
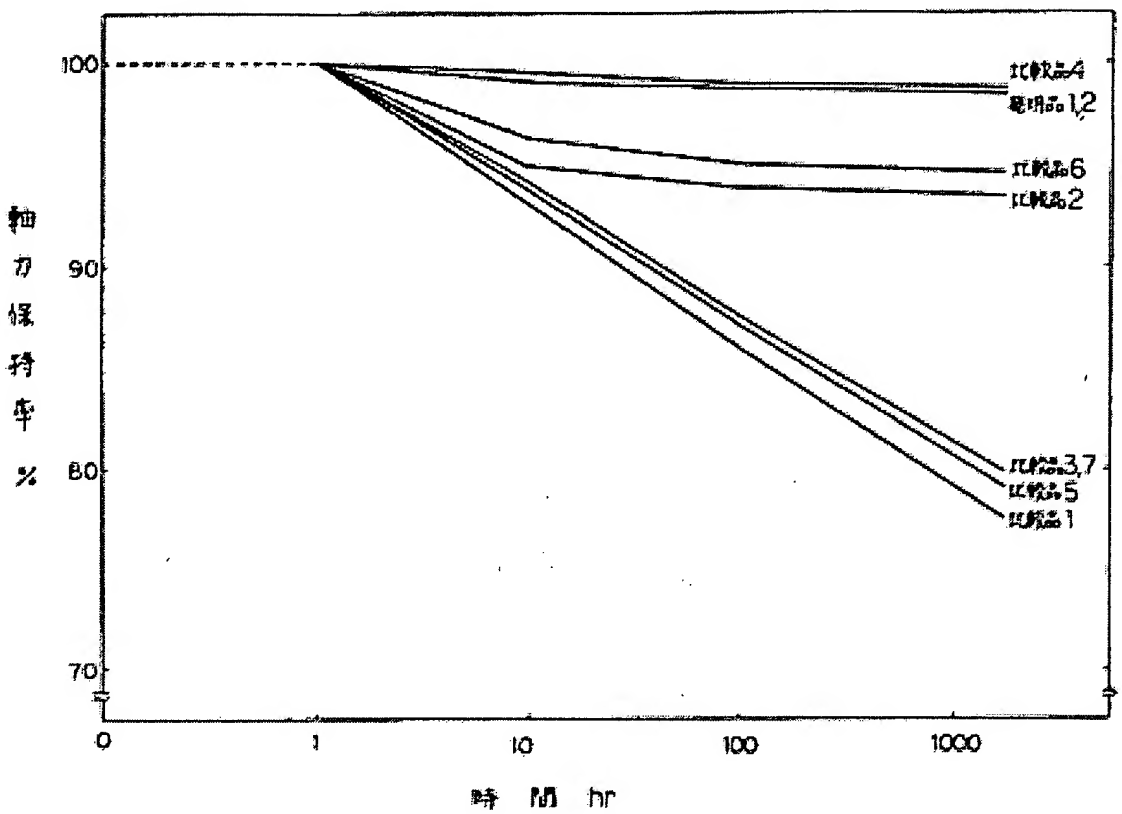


Fig. 11



Vertical axis: axial tension retention (%)

Horizontal axis: Time (hr)

[Second line from the top: Present invention 1 and 2,

Other lines are for comparison products]